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Climate change may alter the circulation patterns of lakes. Traces of such changes can be inferred from lake sediments. The temporal variability within the records can be correlated with climatic and environmental conditions at the time of formation. The presence of varves, their thickness as well as objects and minerals contained in them provide clues about the past water chemistry. We have been investigating processes connecting climate and ecologic response, such as altered circulation patterns.

Over a climate gradient, very deep and purely temperature stratified crater lakes in Japan have been investigated for their circulation patterns. Lakes in a climate of mild winters have a deep water temperature that represents the lowest temperatures reached during the last full circulation. As a consequence, deep water can only be renewed in winters that create low enough water temperatures. If intervals between overturns become too long, oxygen may be depleted. Lakes exposed to cold winters show deep waters below 4˚C. The temperature of maximum density depends on pressure, and as a consequence, such lakes cannot overturn. They remain permanently stratified. However, observations prove that the density stratification is so weak that turbulent transport suffices to keep the deep water well ventilated.

A small number of geochemical cycles sustains permanent stratification of lakes. Photosynthesis forms organic material in the lake. Part of this material settles and decomposes near the sediment. Ions and carbon dioxide as the end products of the decomposition are released into the deep water and contribute to its density. Under favourable conditions, this process can keep the lake permanently stratified. In lakes containing sufficient calcium, photosynthesis may cause calcite precipitation as a by-product. Due to high concentrations of carbon dioxide in the bottom layer calcite may be dissolved as calcium and hydrogen carbonate ions. This geochemical cycle transfers density, i.e. dissolved substances, from the upper water layers (mixolimnion) to the deep water (monimolimnion). Permanent stratification can also result from oxidation and reduction of iron. Dissolved iron is oxidized under mixolimnetic conditions. As a result ferric (FeIII) iron precipitates. In the anoxic monimolimnion, iron may be reduced to ferrous (FeII) iron and dissolve in the monimolimnetic waters. Organic material originating from photosynthetic production in the mixolimnion acts as reducing agent. Manganese shows a similar geochemical cycle.